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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

English Version

Eurocode 3 - Design of steel structures - Part 7: Sandwich panels

Eurocode 3 - Calcul des structures en acier - Partie 7 :
Panneaux sandwich

Eurocode 3 - Bemessung und Konstruktion von
Stahlbauten - Teil 7: Sandwich-Elemente

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 250.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (prEN 1993-7:2025) has been prepared by Technical Committee CEN/TC 250 “Structural Eurocodes”, the secretariat of which is held by BSI. CEN/TC 250 is responsible for all Structural Eurocodes and has been assigned responsibility for structural and geotechnical design matters by CEN.

This document is currently submitted to the CEN Enquiry.

The first generation of EN Eurocodes was published between 2002 and 2007. This document forms part of the second generation of the Eurocodes, which have been prepared under Mandate M/515 issued to CEN by the European Commission and the European Free Trade Association.

The Eurocodes have been drafted to be used in conjunction with relevant execution, material, product and test standards, and to identify requirements for execution, materials, products and testing that are relied upon by the Eurocodes.

The Eurocodes recognize the responsibility of each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level through the use of National Annexes.

Introduction

0.1 Introduction to the Eurocodes

The Structural Eurocodes comprise the following standards generally consisting of a number of Parts:

- EN 1990 Eurocode — Basis of structural and geotechnical design;
- EN 1991 Eurocode 1 — Actions on structures;
- EN 1992 Eurocode 2 — Design of concrete structures;
- EN 1993 Eurocode 3 — Design of steel structures;
- EN 1994 Eurocode 4 — Design of composite steel and concrete structures;
- EN 1995 Eurocode 5 — Design of timber structures;
- EN 1996 Eurocode 6 — Design of masonry structures;
- EN 1997 Eurocode 7 — Geotechnical design;
- EN 1998 Eurocode 8 — Design of structures for earthquake resistance;
- EN 1999 Eurocode 9 — Design of aluminium structures;
- New parts are under development, e.g. Eurocode for design of structural glass.

The Eurocodes are intended for use by designers, clients, manufacturers, constructors, relevant authorities (in exercising their duties in accordance with national or international regulations), educators, software developers, and committees drafting standards for related product, testing and execution standards.

NOTE Some aspects of design are most appropriately specified by relevant authorities or, where not specified, can be agreed on a project-specific basis between relevant parties such as designers and clients. The Eurocodes identify such aspects making explicit reference to relevant authorities and relevant parties.

0.2 Introduction to EN 1993 (all parts)

EN 1993 (all parts) applies to the design of buildings and civil engineering works in steel. It complies with the principles and requirements for the safety and serviceability of structures, the basis of their design and verification that are given in EN 1990 — Basis of structural and geotechnical design.

EN 1993 (all parts) is concerned only with requirements for resistance, serviceability, durability and fire resistance of steel structures. Other requirements, e.g. concerning thermal or sound insulation, are not covered.

EN 1993 is subdivided in various parts:

EN 1993-1, *Design of Steel Structures — Part 1: General rules and rules for buildings*;

EN 1993-2, *Design of Steel Structures — Part 2: Bridges*;

EN 1993-3, *Design of Steel Structures — Part 3: Towers, masts and chimneys*;

EN 1993-4, *Design of Steel Structures — Part 4: Silos and tanks*;

EN 1993-5, *Design of Steel Structures — Part 5: Piling*;

EN 1993-6, *Design of Steel Structures — Part 6: Crane supporting structures*;

EN 1993-7, *Design of steel structures — Part 7: Sandwich panels*.

EN 1993-1 in itself does not exist as a physical document, but comprises the following 14 separate parts, the basic part being EN 1993-1-1:

EN 1993-1-1, *Design of Steel Structures — Part 1-1: General rules and rules for buildings*;

EN 1993-1-2, *Design of Steel Structures — Part 1-2: Structural fire design*;

EN 1993-1-3, *Design of Steel Structures — Part 1-3: Cold-formed members and sheeting*;

NOTE: Cold formed hollow sections supplied according to EN 10219 are covered in EN 1993-1-1.

EN 1993-1-4, *Design of Steel Structures — Part 1-4: Stainless steel structures*;

EN 1993-1-5, *Design of Steel Structures — Part 1-5: Plated structural elements*;

EN 1993-1-6, *Design of Steel Structures — Part 1-6: Strength and stability of shell structures*;

EN 1993-1-7, *Design of Steel Structures — Part 1-7: Plate assemblies with elements under transverse loads*;

EN 1993-1-8, *Design of Steel Structures — Part 1-8: Joints*;

EN 1993-1-9, *Design of Steel Structures — Part 1-9: Fatigue*;

EN 1993-1-10, *Design of Steel Structures — Part 1-10: Material toughness and through-thickness properties*;

EN 1993-1-11, *Design of Steel Structures — Part 1-11: Tension components*;

EN 1993-1-12, *Design of Steel Structures — Part 1-12: Additional rules for steel grades up to S960*;

EN 1993-1-13, *Design of Steel Structures — Part 1-13: Beams with large web openings*;

EN 1993-1-14, *Design of Steel Structures — Part 1-14: Design assisted by finite element analysis*.

All subsequent parts EN 1993-1-2 to EN 1993-1-14 treat general topics that are independent from the structural type like structural fire design, cold-formed members and sheeting, stainless steels, plated structural elements, etc..

All subsequent parts numbered EN 1993-2 to EN 1993-7 treat topics relevant for a specific structural type like steel bridges, towers, masts and chimneys, silos and tanks, piling, crane supporting structures, sandwich panels, etc. EN 1993-2 to EN 1993-7 refer to the generic rules in EN 1993-1 and supplement, modify or supersede them.

0.3 Introduction to EN 1993-7

(1) EN 1993-7 gives supplementary design rules for structural systems and self-supporting systems made of sandwich panels. The focus in EN 1993-7 is on design methods and design rules for individual sandwich panels and structural systems comprised of individual sandwich panels regarding resistance, stability and serviceability.

0.4 Verbal forms used in the Eurocodes

The verb “shall” expresses a requirement strictly to be followed and from which no deviation is permitted in order to comply with the Eurocodes.

The verb “should” expresses a highly recommended choice or course of action. Subject to national regulation and /or any relevant contractual provisions, alternative approaches could be used/adopted where technically justified.

The verb “may” expresses a course of action permissible within the limits of the Eurocodes.

The verb “can” expresses possibility and capability; it is used for statements of fact and clarification of concepts.

0.5 National annex for EN 1993-7

National choice is allowed in this document where explicitly stated within notes. National choice includes the selection of values for Nationally Determined Parameters (NDPs).

The national standard implementing EN 1993-7 can have a National Annex containing all national choices to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

When no national choice is given, the default choice given in this document is to be used.

When no national choice is made and no default is given in this document, the choice can be specified by a relevant authority or, where not specified, agreed for a specific project by appropriate parties.

National choice is allowed in EN 1993-7 through notes to the following clauses:

4.1(2)	4.2(2)	4.3.1.3(1)	4.4.1(3)
4.4.2(4) — 3 times	4.4.3(2)	5.3.1(3)	7.1.3(1)
7.7(1)	7.9(1)	7.10(1)	8.2.2.1(4) — 2 times
8.2.2.2(3)	8.3.1(2)	8.3.2(2)	9.5(1)

National choice is allowed in EN 1993-7 on the application of the following informative annexes:

Annex A	Annex B	Annex C	Annex D
Annex M			

The National Annex can contain, directly or by reference, non-contradictory complementary information for ease of implementation, provided it does not alter any provisions of the Eurocodes.

1 Scope

1.1 Scope of EN 1993-7

(1) This document is applicable for the design of structural or self supporting systems made of sandwich panels with steel faces and core material with a Declaration of Performance (according to EN 14509-1 and EN 14509-2) used as internal and external walls, roofs and ceilings.

1.2 Assumptions

(1) Unless specifically stated, EN 1990, EN 1991 (all parts) and EN 1993-1 (all parts) apply.

(2) The design methods given in EN 1993-7 are applicable if:

- the construction materials and products are as specified in the relevant parts of EN 14509 (all parts), or
- in the relevant material and product specifications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE See the Bibliography for a list of other documents cited that are not normative references, including those referenced as recommendations (i.e. through 'should' clauses) and permissions (i.e. through 'may' clauses).

EN 1990:2023, *Eurocode — Basis of structural and geotechnical design*

EN 1991 (all parts), *Eurocode 1 — Actions on structures*

EN 1993-1 (all parts), *Eurocode 3 — Design of steel structures*

EN 14509 (all parts)¹, *Factory-made double skin metal faced insulating sandwich panels*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 14509 (all parts) and the following apply.

3.1.1

bond

adhesion between the face(s) and the core normally provided by an adhesive or by auto-adhesion

3.1.2

ceiling

covering over an internal area

3.1.3

core

layer of material, having thermal insulating properties, which is bonded between two steel faces

¹ At draft stage.

3.1.4**edge****longitudinal edge**

side of the panel

3.1.5**face**

flat, lightly profiled or profiled steel sheet firmly bonded to the core

3.1.6**flat face**

face without any rolled or pressed profiling, or raised strengthening trapezoidal section

3.1.7**global buckling**

instability characterized by a translation of the cross-section

Note 1 to entry: Global buckling modes of axially loaded sandwich panels include flexural modes with or without wrinkling of the face under compression.

3.1.8**joint**

interface between two panels where the butt edges have been designed so that the panels can be joined in the same plane

Note 1 to entry: The joint can incorporate interlocking parts that enhance the mechanical properties of the system as well as improve the thermal, acoustic and fire performance and restrict air movement.

Note 2 to entry: The term 'joint' does not refer to a junction between cut panels or a junction where the panels are not installed in the same plane.

3.1.9**lightly profiled face**

face with a rolled or pressed profiling not exceeding 5 mm in depth

3.1.10**profiled face**

face with a rolled or pressed profiling exceeding 5 mm in depth

3.1.11**sandwich panel**

building product consisting of two steel faces positioned on either side of a core

Note 1 to entry: The core is firmly bonded to both faces so that the three components act compositely when under load.

3.1.12**structural system**

structure consisting of sandwich panels

3.1.13**wrinkling**

cross-sectional instability in which the face under compression undergoes out-of-plane plate bending deformations (local buckling)

3.1.14

line loads perpendicular to the span

loads that are applied on the whole width of the panel with a load application length corresponding to the minimum support width L_s according to EN 14509 (all parts)

3.1.15

point loads

loads applied over a width smaller than the whole panel width and/or a length shorter than the minimum support width L_s according to EN 14509 (all parts)

3.2 Symbols and abbreviations

For the purpose of this document the following symbols apply:

3.2.1 Latin upper case symbols

A_c	cross sectional area of the core
A_{Fi}	cross-sectional areas of the faces
A_{F1}, A_{F2}	cross section of the inner and outer steel face
A_o	cross sectional area of the opening
B	panel width
B_{eff}	effective width
$B_{eff,w}$	effective width for bending moment
$B_{eff,v}$	effective width for shear forces
$B_{eff,min}$	minimum effective width for bending and shear respectively
B'_{eff}	reduced effective width
B_s	bending stiffness
C_w	correction factor point loads
C_v	correction factor point loads
F	support reaction
E	modulus of elasticity
$F_{a,plane}$	force in plane
$F_{a,perp}$	force perpendicular to the plane
$F_{a,Rd}$	resistance force of the panels and its assemblies
$F_{a,Ed}$	horizontal seismic force acting on a non-structural element
F_{Ed}	(support reaction) force at ULS/SLS
$F_{t,Rk}$	characteristic tensile resistance of a fastener
$F_{va,Rd}$	dynamic shear capacity of each fastener
$F_{va,Ed}$	seismic shear force of each fastener during the test
$F_{ta,Rd}$	dynamic tension capacity of each fastener
$F_{ta,Ed}$	seismic tension force of each fastener during the test

G_{Cm}	mean shear modulus of the core
G_{Ct}	time dependent shear modulus of the core material
$G_{Ct,eff}$	time and load dependent effective shear modulus of the core considering creep
I_{F1}	second moment of area of the profiled face
L	span, member length, length of specimen tested
L_{cr}	buckling length
L_S	width of support
$L_{S,eff}$	effective width at the support
M_{Ed}	bending moment in the critical cross section caused by eccentricity of normal force and loads perpendicular to the panel
M_S	sandwich bending moment
$N_{cr,S}$	critical buckling load taking into account the shear deformation
N_{Ed}	normal force in the critical cross section at ULS
N_{mt}	normal force caused by medium-term loads (i.e. load duration less than permanent, snow)
N_{pt}	normal force caused by permanent loads
R_G	degree of reflection relative to magnesium oxide = 100 %
S	Shear Stiffness, soil factor as provided by EN 1998-1-1
$(T_1 - T_2)$	thermal gradient
$V_{Fi,Ed}$	design shear force in the considered profiled face in ULS
$V_{Fi,Rd}$	design value of the shear resistance of the considered profiled face
V_S	shear force in the core
$V_{S,Ed}$	design shear force in core in ULS/SLS

3.2.2 Latin lower case symbols

b_e	width of load introduction
d_c	continuous core thickness
e	is the distance of the centroids of the faces
e^*	geometric eccentricity of N_{Ed} at point of load introduction
e_y	distance between load introduction and panel edge
f_y	yield strength of considered face
f_{Cc}	compressive strength of the core
f_{Cv}	shear resistance of the core
$f_{Cv,long}$	reduced long-term shear strength
$f_{Cv,0}$	reduced shear strength due to the opening
f_u	nominal ultimate tensile strength
f_y	nominal yield strength

g	total mass
k	support distribution parameter
k_{pl}	reduction factor for load introduction of point loads
k_s	reduction factor for openings
m_a	mass of a sandwich panel
n	number of fasteners or number of fasteners of the stressed edge in line with acting force
o	overhang of the panel
t	design thickness of the steel face
t_{load}	load duration for actions with other durations as service life of the structure
t_{nom}	nominal thickness of the steel face
t_N	nominal thickness
t_{tol}	negative tolerance
t_{zinc}	total thickness of the zinc layers (or similar protective coating)
u	head displacement
u_{Cd}	limitation of head displacement
q	uniformly distributed load
q_a	behaviour factor of a non-structural element

3.2.3 Greek symbols

α^{II}	increase factor considering II. order effects
α_{gr}	the design ground acceleration
α_T	$= 1,2 \cdot 10^{-6} [1/K]$ for structural steel according to EN 1993-1-1 and EN 1993-1-3
β	$= b/B$ ratio of opening width b to total width of sandwich panel B
$\gamma_{M0,ULS}$	partial factor for the yielding of a face at ULS
$\gamma_{M0,SLS}$	partial factor for the yielding of a face at SLS, see Table 4.1
$\gamma_{M1,SLS}$	partial factor for wrinkling of a face at SLS
$\gamma_{M2,SLS}$	partial factor for the failure of a fastener at SLS
$\gamma_{M3,SLS}$	partial factor for shear failure of core at SLS
$\gamma_{M4,SLS}$	partial factor for the crushing of the core at SLS
$\gamma_{M1,ULS}$	partial factor for wrinkling of a face at ULS
$\gamma_{M2,ULS}$	partial factor for the failure of a fastener at ULS
$\gamma_{M3,ULS}$	partial factor for the shear failure of the core
$\gamma_{M4,ULS}$	partial factor for the crushing of the core at ULS
$\delta_{a,Rd}$	displacement capacity of the panels and its assemblies obtained by testing
$\delta_{a,Ed}$	displacement (e.g. drift between storeys) imposed to the panel and its assemblies by the deformation of the supporting structure
$\sigma_{Fi,Ed}$	design stress resulting from normal and bending stresses in considered face at ULS/SLS

$\sigma_{O,Rd}$	reduced wrinkling strength due to the opening
σ_w	wrinkling strength of considered face
$\sigma_{wR,down}$	wrinkling strength at an internal support
$\sigma_{wR,T,down}$	wrinkling strength at an internal support at elevated temperature
$\sigma_{wR,up}$	wrinkling strength at an internal support
$\sigma_{wR,T,up}$	wrinkling strength at an internal support at elevated temperature
$\sigma_{w,s,down}$	wrinkling strength at an internal support with fully used compressive strength
$\sigma_{w,s,up}$	wrinkling strength at an internal support with fully used design values for tension forces for a defined screw type
$\sigma_{w,T}$	wrinkling strength of considered face at elevated temperature
$\tau_{C,Ed}$	shear stress in the core in ULS
$\tau_{C,Ed,creep}$	combination of the additional shear stresses resulting from creeping (additional parts according to stress redistribution due to long term loads, like self-weight and snow)
$\tau_{C,Ed,long}$	combination of all shear stresses resulting from long-term loading (e.g. self-weight and snow)
$\tau_{C,Ed,short}$	combination of all shear stresses resulting from short-term loading (e.g. wind and temperature)
φ_{mt}	creep coefficient for medium-term loads
φ_{pt}	creep coefficient for permanent loads
φ_t	creep coefficient
φ_{2000}	creep coefficient at 2 000 h
φ_{100000}	creep coefficient at 100 000 h
$\theta_{a,Ed}$	associated angle of imposed displacement $\delta_{a,Ed}$
$\theta_{a,Rd}$	associated angle of displacement capacity $\delta_{a,Rd}$

3.2.4 Abbreviations

EPS	expanded polystyrene foam
DoP	declaration of performance
PIR	rigid polyisocyanurate foam
PUR	rigid polyurethane foam
SLS	serviceability limit state
ULS	ultimate limit state
XPS	extruded polystyrene foam

3.2.5 Symbols for member axes/Cross-sectional dimensions

X	axis parallel to the direction of span
Y	axis parallel to the direction of panel width
Z	axis parallel to the direction of panel thickness

3.2.6 Geometrical data

(1) The cross-section dimensions of a sandwich panel are shown in Figure 3.1. Faces with $d_i \leq 5$ mm are lightly profiled.

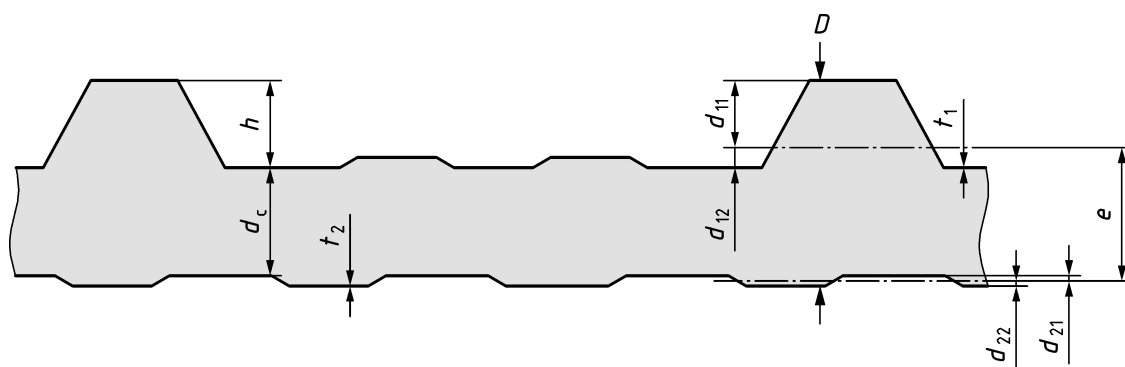


Figure 3.1 — Panel cross-section with profiled face

all dimensions in mm

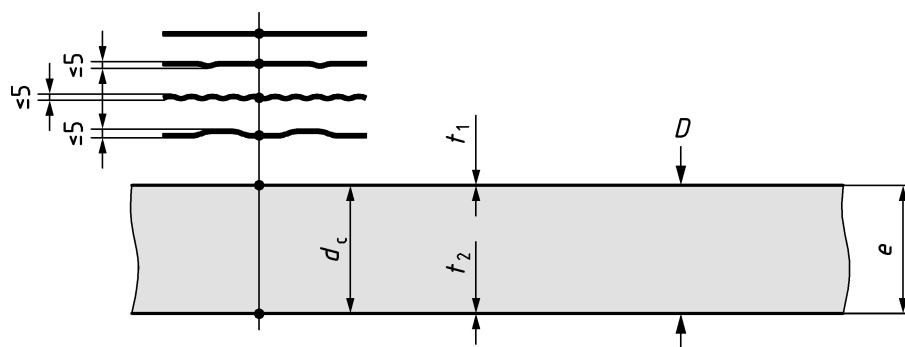


Figure 3.2 — Panel cross-section with examples of lightly profiled faces

NOTE e is the distance of the centroids of the two faces. For $d_{i,j}$ see Figure 3.1.

4 Basis of Design

4.1 Requirements

(1) The design of sandwich panels shall be in accordance with the general rules given in EN 1990 and EN 1991 (all parts) and the specific design provisions for steel structures given in EN 1993-1 (all parts).

(2) For other metallic faces the same principles may be used.

NOTE Application of EN 1993-7 for other materials can be given by the National Annex.

(3) EN 1993-7 should be used in conjunction with:

— the parts of EN 1992 (all parts) to EN 1999 (all parts) where steel structures or steel components are referred to within those documents

— EN standards for construction products relevant to steel structures.

NOTE EADs and ETAs are also for construction products relevant to steel structures.

4.2 Principles of limit state design

(1) The design rules defined in EN 1990 apply.

(2) Because of the high effect of the temperature gradient and the creeping of the core material specific combination factors are defined in 4.4.2.

NOTE Unless the National Annex defines otherwise, the design resistance in SLS and ULS can be expressed in relation to the span of the panel (e.g. using load-span tables or graphs or calculation notes).

4.3 Actions and environmental influences

4.3.1 Permanent actions

(1) The permanent actions to be taken into account in the design shall be obtained from the relevant part of EN 1991 and from specifications of this document and should include the following:

- self-weight of the panel;
- self-weight of any permanent components of the structure and installation that apply load to the panel;
- permanent imposed deformations (calculated using nominal values relevant to the specific application).

(2) Creep of the core material should be taken into account in the design for panels used as a roof, ceiling or axially loaded wall panel. This may cause a change in both stresses and deformations within time.

NOTE Creeping is also relevant for the variable action “snow”.

4.3.2 Variable actions

(1) The variable actions shall be obtained from the relevant part of EN 1991 and should include the following, where they are relevant:

- snow loads;
- live loads;
- wind loads;

- execution loads;
- climatic effects (e.g. due to a temperature difference between the faces of a panel).

4.3.3 Temperature actions

(1) The temperature gradients resulting from the difference between the outside temperature T_1 and the inside temperature T_2 are variable actions, for SLS and ULS both. They can also cause creeping effects.

(2) Depending on the latitude, on the height above sea level and on the distance from the sea, four different minimum winter temperature levels T_1 are used throughout the continent of Europe: 0°C, -10°C, -20°C and -30°C. Negative inner and outer environment temperatures are defined in EN 1991-1-5. The temperature of the external face of a roof panel with a snow load is 0°C.

(3) The temperature T_1 of the outer face has a maximum summer value which depends upon the location (country), colour and reflectivity of its surface. Values of T_1 , which are minimum for ULS calculations and which are suitable for serviceability calculations, are given as follows:

Table 4.1: (NDP) Maximum temperature of outer face

Colour Group	Colour	Reflection degree	Temperature T_1
colour group 1	very light colours	$R_G = 75-90$	$T_1 = +55\text{ °C}$
colour group 2	light colours	$R_G = 40-74$	$T_1 = +65\text{ °C}$
colour group 3	dark colours	$R_G = 8-39$	$T_1 = +80\text{ °C}$
R_G is the degree of reflection relative to magnesium oxide = 100 %.			

(4) In special cases, the maximum temperature of a face exposed to the sun can be determined more precisely on the basis of the actual colour used.

(5) If national specifications do not give values for internal (ambient) temperatures, the values for the temperature of the inside face are given below:

Summer: $T_2 = +25\text{ °C}$

Winter: $T_2 = +20\text{ °C}$

(6) Where internal temperatures are specific to the use of the building (e.g. cold stores, bakeries) the temperature can be provided by the designer or building user.

(7) The given values for temperature at the external faces can be taken for both the ULS and the SLS.

(8) Recommended is the use of ECCS Recommendation No. 136 [7]. In Table B.1 of [7] definitions of temperature related to colours and colour groups 1 to 3 are given as examples.

NOTE 1 For the determination of the temperature of the inner and outer faces the rules in 4.3.3 apply, unless the National Annex gives different values.

NOTE 2 The greatest difference between the inside and outside temperatures can arise during installation.

NOTE 3 Thermal gradient causes thermal bow. Thermal elongation of panels is not covered in this document. This effect concerns only special cases with long panels greater than 20 m, especially at end laps.

4.3.4 Seismic actions

(1) Seismic actions may be accounted by equivalent static loads, according to the relevant part of EN 1998.

4.4 Verification by the partial factor method

4.4.1 Design values of actions

(1) The principles and design provisions in this document are in accordance with EN 1990. However, the recommended values of combination factors of actions and material partial factors are particular to sandwich panels and reflect the special characteristics of this application, notably the increased importance of temperature stresses and deflections, the potentially highly variable nature of characteristics influenced by the properties of the core material and the influence of creep.

(2) Values of the partial factors for actions γ_F are defined in EN 1990.

NOTE 1 Temperature is often the dominant load case and can cause greater stresses and/or deflections than wind, snow or imposed load.

NOTE 2 More information on load combination is given in Bibliography [7].

NOTE 3 The partial factor for actions for additional effects (e.g. stresses or deflections) due to creeping is $\gamma_{F,creep} = 1,0$ for ULS and SLS, unless the National Annex gives a different value.

4.4.2 Combination of actions

(1) The combination of actions for persistent and transient (fundamental) design situations for the verification of the ULS should be taken according to EN 1990:2023, Formulae (8.12), (8.13) or (8.14).

(2) The verification of the SLS should include consideration of both stresses and deflections.

(3) The characteristic combination of actions for the verification of the SLS should be taken according to EN 1990:2023, Formula (8.29). The characteristic combination should be used to ensure that there is no visible damage to the panel and to limit deflections at the SLS.

(4) For stress redistribution and the additional deflections due to creeping the same combination factors as for the initial type of action may be used.

NOTE 1 The values of combination factors ψ_0 are given in EN 1990 unless the National Annex gives different values.

NOTE 2 Unless the National Annex gives different values, deflections caused by wind or snow can be reduced both to 75 % when combined with other actions.

NOTE 3 Unless the National Annex gives different values, factor $\psi_0 = 1,0$ can be used if the winter temperature $T_1 = 0\text{ }^{\circ}\text{C}$ is combined with snow.

4.4.3 Design values of material properties

(1) The values for partial factors γ_m as given in Table 4.2 (NDP) are recommended.

NOTE 1 The values for partial factors γ_m are given in Table 4.2 unless the National Annex gives different values. The National Annex can give information for the application based on test results according to EN 14509 (all parts).

NOTE 2 The nominal values given in Table 4.2 are based on past experiences and are examples of “worst case” values that correspond to panels with high variation in mechanical properties.

Table 4.2: (NDP) Partial factors γ_{Mi}

Property to which γ_M applies	Limit state			
	ULS		SLS	
	Symbol		Symbol	
Yielding of a face, Shear failure of a profiled face, Support reaction capacity of a profiled face	$\gamma_{M0,ULS}$	1,1	$\gamma_{M0,SLS}$	1,0
Wrinkling of a face in the span and at an intermediate support (interaction with support reaction)	$\gamma_{M1,ULS}$	2,8	$\gamma_{M1,SLS}$	1,4
Failure of a fastener Failure of an element at a point of connection	$\gamma_{M2,ULS}$	1,33	$\gamma_{M2,SLS}$	1,33
Shear failure of the core	$\gamma_{M3,ULS}$	2,4	$\gamma_{M3,SLS}$	1,3
Crushing of the core	$\gamma_{M4,ULS}$	2,4	$\gamma_{M4,SLS}$	1,3
In accidental situations $\gamma_{Mi,acc}$ values can be taken as $\gamma_{Mi,acc} = \gamma_{Mi,SLS}$.				

5 Materials

5.1 General

(1) For the design of sandwich panels according to this document the necessary material parameters are given in Annex M and are defined by product standard EN 14509 (all parts).

5.2 Face material

(1) The design thickness of a steel face should be taken from Formula (5.1)

$$t = t_{nom} - t_{zinc} - 0,5 t_{tol} \quad (5.1)$$

with

t design thickness of the steel face;

t_{nom} nominal thickness of the steel face;

t_{zinc} total thickness of the zinc layers (or similar protective coating);

t_{tol} negative tolerance according to EN 10143.

(2) If the special tolerance (S) according to EN 10143 is adhered to, the design thickness should be taken from Formula (5.2) (without reduction to the tolerance).

$$t = t_{nom} - t_{zinc} \quad (5.2)$$

(3) The design thickness of other steel faces, such as those made of stainless steel should be determined so that they represent statistically reliable minimum thickness values. For these materials the design thickness should be taken from Formulae (5.3) and (5.4)

$$t = t_{\text{nom}} - 0,5 t_{\text{tol}} \quad \text{for normal tolerances} \quad (5.3)$$

and

$$t = t_{\text{nom}} \quad \text{for special tolerances} \quad (5.4)$$

(4) The design provisions according to EN 1993-1-3 may be used alternatively.

5.3 Core material - The influence of time on shear deformations of the core

(1) The stresses and deflections due to creeping of the core in shear require a special consideration, taking into account the reduced value of the shear modulus G_{Ct} .

(2) Where relevant, the reduced value of the shear modulus G_{Ct} should be determined for a time period of 2 000 h for snow load and 100 000 h for permanent actions (dead load). The reduced shear modulus is given by Formula (5.5):

$$G_{\text{Ct}} = \frac{G_{\text{Cm}}}{1 + \varphi_t} \quad (5.5)$$

with

φ_t creep coefficient;

G_{Cm} mean shear modulus of the core;

G_{Ct} time dependent shear modulus of the core material.

(3) For a load duration $t_{\text{life}} > 100\,000$ h a creep coefficient φ_{pt} may be defined according to Formula (5.6):

$$\varphi_{\text{pt}} = \varphi_{2000} + (\varphi_{100000} - \varphi_{2000}) \frac{\lg t_{\text{life}} - \lg 2000}{\lg 100000 - \lg 2000} \quad (5.6)$$

with

t_{life} load duration (in accordance with the service life of the structure) [h];

φ_{2000} creep coefficient at 2 000 h according to Annex M;

φ_{100000} creep coefficient at 100 000 h according to Annex M;

NOTE The National Annex can give information on t_{life} and service life of the structure.

(4) For actions with other durations a creep coefficient φ_{mt} (medium term loads) may be defined according to Formula (5.7):

$$\varphi_{\text{mt}} = \varphi_{2000} + (\varphi_{100000} - \varphi_{2000}) \frac{\lg t_{\text{load}} - \lg 2000}{\lg 100000 - \lg 2000} \quad (5.7)$$

with

t_{load} load duration for actions with other durations as service life of the structure [h].

(5) For the application of Formulae (5.6) and (5.7) the declared values for φ_{2000} and φ_{100000} may be used, for they are sufficiently accurate. Formula (5.6) is equivalent to the formulae for the extrapolation of creep coefficients based on test results in EN 14509 (all parts).

6 Durability

(1) The durability requirements are defined in EN 14509 (all parts).

7 Structural Analysis

7.1 Structural modelling for global analysis

7.1.1 General

(1) In the determination of the stress resultants and deflections, the shear flexibility of the core shall be taken into account. For this purpose, a constant value of the shear modulus (mean value) of the core corresponding to an average value at normal indoor temperature should be used.

(2) One of the following methods of global analysis should be used:

- elastic global analysis;
- plastic global analysis.

(3) Elastic global analysis should be used for the design in SLS and may be used for the design in ULS.

(4) Plastic global analysis may only be used for the design in ULS (e.g. with hinges over intermediate supports). Plastic analysis shall not be used when the first failure mode is a shear failure of the core, unless the core material has adequate plastic shear capacity.

7.1.2 Elastic global analysis

(1) The action effects (bending moments, normal and shear forces, deflections) resulting from the combination of all actions applied to the sandwich panels should be determined by using the theory of elasticity, taking into account the shear flexibility of the core material.

NOTE Formulae for some frequently encountered cases are given in Annex A.

7.1.3 Plastic global analysis

(1) In plastic global analysis at the ULS, a continuous multi-span sandwich panel may be replaced by a series of simply supported panels with zero bending resistance at intermediate supports. In this calculation model, stresses caused by the temperature difference between the faces vanish in sandwich panels with flat or lightly profiled faces on both sides.

NOTE At ULS the residual bending moment at an intermediate support is zero, unless the National Annex gives values for this.

7.2 Specifications for sandwich panels

7.2.1 Sandwich panels with flat or lightly profiled faces

(1) In case of sandwich panels with flat faces or with faces which are lightly profiled (definition: see 3.2.6) on both sides, the bending stiffness of the faces may be neglected, i.e. the bending moment is carried by normal forces in the faces and the shear force by shear stresses in the core.

NOTE 1 Stress resultants and deflections for single span sandwich panels under uniformly distributed loads or temperature gradients can be calculated using the formulae given in Annex A.

NOTE 2 Stress resultants, support reactions and deflections for two or three span sandwich panels with equal spans under uniformly distributed loads or temperature gradients can be calculated using the formulae given in Annex A.

7.2.2 Sandwich panels with one or two profiled faces

(1) In case of sandwich panels with one or two profiled faces (definition: see 3.2.6) the bending stiffness of the profiled faces has to be taken into account, hence the sandwich panel is itself statically indeterminate in addition to any global structural indeterminacy that may be present.

NOTE Provisions for simply supported or two span sandwich panels with profiled faces and equal spans are given in Annex A.

(2) Multi-span sandwich panels with profiled faces may be designed by numerical calculation considering the influence of shear flexibility of the core and the bending stiffnesses of each profiled face.

7.3 General principles for cross-sectional analysis

7.3.1 General

(1) For the range of deformations to be considered, except where “plastic hinges” are assumed in plastic design, it may be assumed that the materials of the core and faces remain linearly elastic. It may also be assumed that the elongational stiffness of the core is so small in comparison to that of the faces that the influence of longitudinal normal stresses in the core may be neglected. The load bearing behaviour of a sandwich panel may then be divided into two components (see Figure 7.1, Figure 7.3 and Figure 7.5):

a) For bending moments:

into a moment component M_F in the steel faces and a moment component M_S (the sandwich part) resulting from the normal forces N_{F1} and N_{F2} in the steel faces multiplied by the distance of the centroids e .

b) For shear forces:

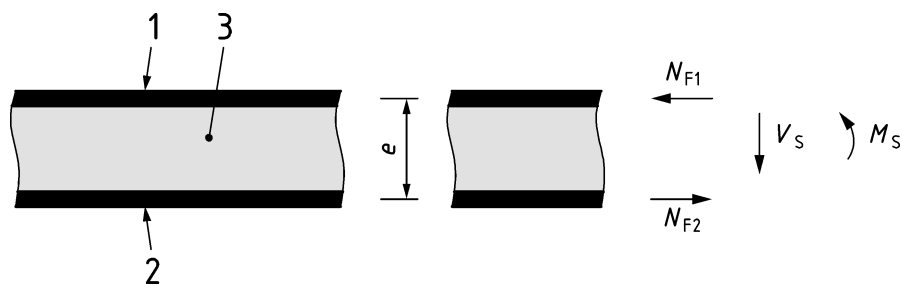
into a shear force component V_F in the steel faces and a shear force component V_S in the sandwich part of the section.

NOTE 1 For detailed information on the calculation see also Bibliography [10].

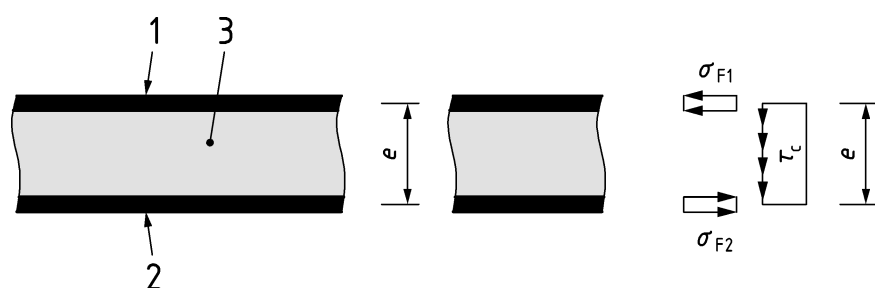
NOTE 2 Normal forces N_{F1} and N_{F2} cause a uniform compressive and tensile stress distribution over the external and internal faces, while the bending moments M_{F1} and M_{F2} result in normal stresses which vary linearly over the depths of the faces. Local buckling of compressed parts of a face profile makes the normal stress distribution in the face nonlinear.

NOTE 3 The shear force V_S causes a constant shear stress distribution τ_c over the depth of the core, when the compressive and tensile rigidity of the core layer in the longitudinal direction of the sandwich panel is ignored. The shear forces V_{F1} and V_{F2} cause shear stresses τ_{F1} , τ_{F2} in the face layers with significant bending rigidity, see Figure 7.4 and Figure 7.6.

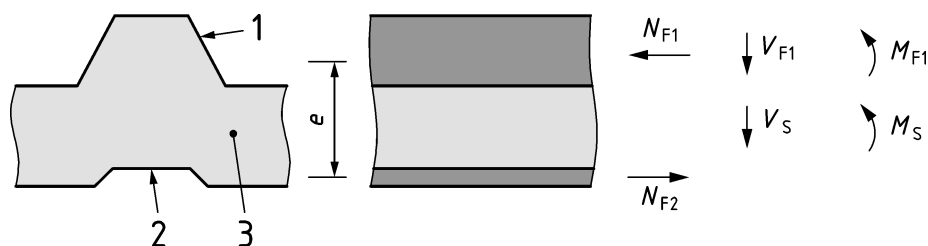
(2) If the faces of a sandwich panel are flat or lightly profiled, the bending stiffness of the faces ($B_{F1} = E_{F1} \times I_{F1}$, $B_{F2} = E_{F2} \times I_{F2}$) is small and has a negligible effect on the stress distributions and deflections of the panel. In this case, the bending stiffness of the faces should be neglected ($B_{F1} = B_{F2} = 0$) in the analysis and the calculations should be based on the stress resultants $M_S = e \times N_{F1} = e \times N_{F2}$ and V_S only (see Figure 7.1).

**Key**

- 1 face 1
- 2 face 2
- 3 core

Figure 7.1 — Stress resultants in a sandwich panel with flat or lightly profiled faces**Key**

- 1 face 1
- 2 face 2
- 3 core

Figure 7.2 — Stress distribution over the cross-section in a sandwich panel with flat or lightly profiled faces**Key**

- 1 face 1
- 2 face 2
- 3 core

Figure 7.3 — Stress resultants in a sandwich panel with one profiled face